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The measurement of surface wind

by

R. Frith

(Meteorological Office)

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Introduction

There is a twofold demand for accurate surface wind data. On the one hand, Aerodrome Control Officers and air crew wish to know, at all times, what the wind is on the runway. On the other hand a variety of users (architects, agriculturists etc.) wish to be provided with accurate information about wind régimes over more or less extensive areas and periods.

These two demands pose rather different problems. On an airfield the problem is to assess the wind (speed, direction, gustiness) on the runway from readings of a nearby anemometer exposed as may be. The World Meteorological Organisation's definition of 'surface wind' is the wind at a height of 10 m. in an open situation. Since the vicinity of a runway is an open situation, and since 10 m. seems to have become the accepted height of measurement for aviation purposes, the problem reduces to obtaining the 'surface wind', as defined by W.M.O., from the readings of a nearby anemometer which is perhaps not exposed in an open situation, and is perhaps not exposed at a height of 10 m.

For other purposes the problem is this:-

(i) What is the best definition of the concept of a 'representative wind' and how should this be derived from instruments exposed as may be?

(ii) Given, by observation or interpolation, a 'representative wind' for a locality, how can we best estimate the actual wind at any place or height taking account of terrain and obstacles?

The W.M.O. definition of a 'surface wind' can perhaps be accepted as the 'representative wind'. It would probably be unreasonable to attempt to make the measurement more 'representative' by removing from it any component due, for example, to local topography or to a sea breeze.

We have, therefore to consider:-

(a) how to assess the 'surface wind' (i.e., the wind at 10 m. in an open situation) from an anemometer exposed as may be; and

(b) how, from assessments at a network of stations, we can best estimate the actual wind at any place or height taking account of terrain and obstacles.

If an anemometer is exposed at a height of 10 m. in an open situation, then it measures, directly, the surface wind as defined by W.M.O. If it is exposed at a height different from 10 m., or if the site is not open, then the reading may have to be reduced in some way in order to obtain an accurate assessment of the 'surface wind'.

/Height

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Height of exposure

A good deal of field work has been done on the variation of wind with height under various conditions of stability, wind speed and surface roughness. Deacon (1) and Giblett (2) quote results which indicate that the Hellmann formula, which is used in the Meteorological Office for the reduction of anemometer readings, may give results which are in error by as much as 20 per cent. It has been suggested that an observational accuracy, after reduction to the standard height of 10 m., of ± 5 per cent. or one knot, whichever is the greater, in speed (both mean speed and gust speed) and ± 5 degrees in direction is desirable.

Probably enough is now known to enable corrections for height to be made with this accuracy up to a height of, perhaps, 70 feet. It is doubtful whether readings from anemometers exposed at heights above 70 feet could be reduced with the required accuracy except when the wind is strong.

The effect of poor exposure

Where an exposure is poor it is usually due to the presence near the anemometer of obstacles, such as buildings and trees*.

The effect of isolated obstacles has received a certain amount of qualitative study both in wind tunnels and in the field, the latter mostly in connection with wind breaks. It is fairly well established, for example, that at a height of about three times the height of an isolated bluff obstacle the wind characteristics are practically unchanged by the obstacle; but there seems to be little precise information about the effect inside the disturbed air flow.

Where an instrument has a poor exposure an appropriate reduction formula can best be determined by an on-site investigation; by erecting an anemometer at 10 m. on a nearby open site and comparing the readings over a long period.

It is desirable, however, that there should be some fairly simple rule of thumb which would indicate whether any particular exposure, or proposed exposure, is:-

(a) good (i.e., no corrections or reductions needed);

(b) poor (i.e., acceptable but reductions or corrections needed);

(c) not acceptable (i.e., such that no practicable reduction or correction formulae could be found to obtain wind speed, direction and gustiness with the required accuracy).

A large number of comparisons at existing sites would probably enable such a rule to be formulated; but it might be useful to carry out a special and detailed field investigation into the effect of a single obstacle. This would be simpler to carry out, and would be more revealing, than a wind tunnel experiment.

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*The present method of dealing with a poor exposure is for some inspector to form an estimate of an 'effective height'. This 'effective height' is defined as "the height at which a properly exposed anemometer would register a mean wind equal to that recorded by the anomometer in question". It might be better if the anemometer reading were corrected to indicate the undisturbed wind at the height of the anomometer, and this corrected reading reduced to 10 m.

Summary and proposed investigations

An observational accuracy, after reduction to the standard height of 10 m., of ± 5 per cent in speed, and of ± 5 degrees in direction, cannot be achieved until more is known about the effect of local obstacles. Nor can it be achieved using our present universal reduction formula. It is proposed that:-

(i) on-site investigations be carried out at a number of stations where the exposure of the anomometer is not good;

(ii) a study of the literature be made to assess the accuracy with which reductions to a standard height can be made under various conditions of surface roughness, wind speed and stability;

(iii) a field investigation be carried out into the effect of a single obstacle to determine:

(a) at what height, and how far away, the flow is unaffected by the obstacle:

(b) to what extent it is possible to correct for the presence of the obstacle.

References:

(1)	Deacon, E.L.	1949	Q.J. Roy.Met.Soc., 75
(2)	Giblett, M.A.	1932	Geophys. Mem. Met.Off. London, No. 54

Appendix on the problem of interpolation in the horizontal

By definition the 'surface wind' is the wind at 10 m. in an open situation. If an anemometer can be exposed at 10 m. in an open situation then the 'surface wind' can be measured with high accuracy. In other circumstances it is necessary to 'reduce' the readings to allow for the effects of exposure at heights differing from 10 m. and exposure in non-open situations. The preceding sections have discussed the problems involved in this reduction.

High accuracy in measurement and in reduction is, however, of little value unless interpolation can be carried out with comparable accuracy. In the absence of topographical effects and provided there are no variations in surface roughness, there is no obvious reason why interpolation (of statistics, or of means over not too short a period) should not give results with an accuracy comparable with that of the basic data. The results of the interpolation would, of course, refer to the standard height of 10 metres and extrapolation to other heights would have to be made with care. In particular, extrapolation to heights above 25 metres could probably only be made with precision when the wind was strong.

Where there are variations of surface roughness this would have to be taken into account. In assessing the surface roughness, the nature of the actual surface (short grass, long grass, bare soil, snow, crops, water, etc.) must be considered and also the absence or presence of fences or walls, trees, houses, etc. Results quoted by Deacon suggest that with a long fetch over short grass, the wind at 10 metres would be 5 - 10% greater than over long grass, and 5 - 10% less than over snow.

Where marked topographical effects exist, interpolation to the accuracy specified must frequently be impossible. There is, nevertheless, a growing interest, particularly among agriculturists, in the variations of the surface winds in hilly country, and some sort of pilot experiment might be worth while. It would be preferable that any such experiment should be designed and carried out by someone directly concerned - perhaps an agricultural meteorologist.